# Injectors with Au
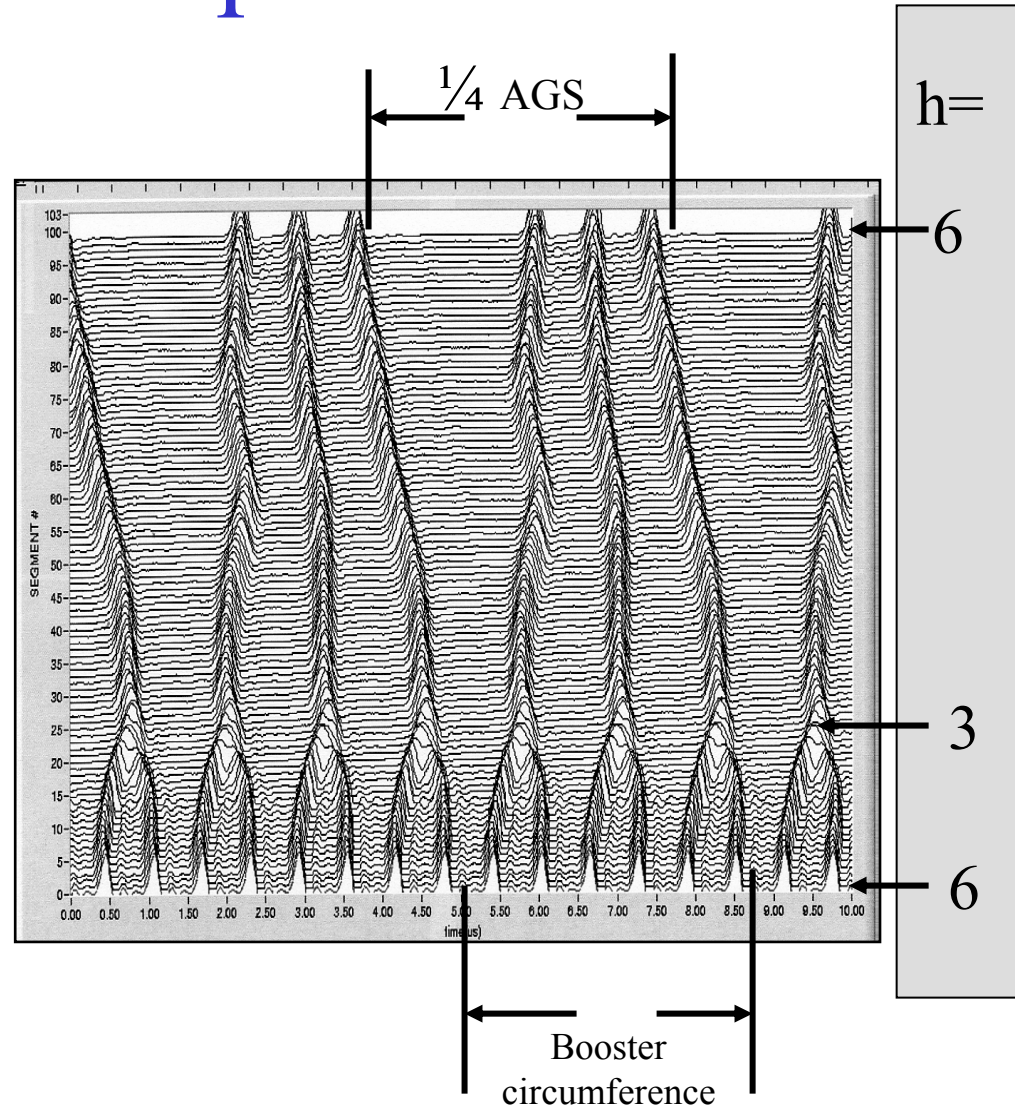# (bunch intensity, Booster merge)

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RHIC Retreat 06

July 10, Danfords'

# New RF Gymnastics

- *Menu: low to high priority order*
  1. Double bunch intensity with merge/squeeze in the Booster
  2. Improvements to AGS-to-RHIC synchro
  3. Replace de-bunch/re-bunch at AGS injection with 24>8>4 adiabatic merge
- *Appetite: a hungry collider*
- *Currency: man hours*

# Merge and Squeeze

- We now put one Booster fill into one RHIC bunch

- This will put two Booster fills into one RHIC bunch

- Possible because longitudinal emittance blow-up at BTA can be reduced to ½

  - BTA foil uniformity

  - Less frequency mismatch

  - Voltage match becomes possible
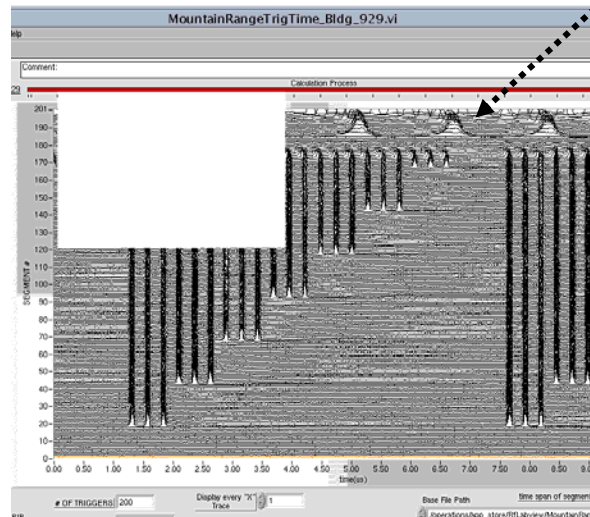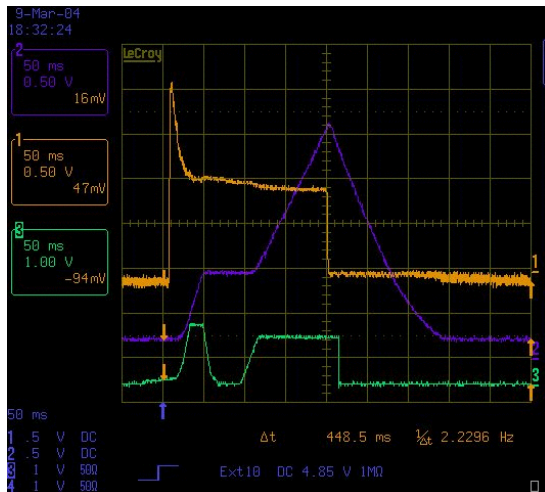


¼ AGS

h=

6

3

6

Booster circumference

# Merge and Squeeze

## Status

- Developed in 04

- Tested in one RHIC 6-bunch ramp

- *bricolage* llrf implementation
( not within the control system)

## Results

- Tested only with 7 Booster cycles
- RHIC bunch intensity = 1.6 x $10^9$ ions
- Longitudinal emittance =~equal to non-merged (h=4 acceptance)
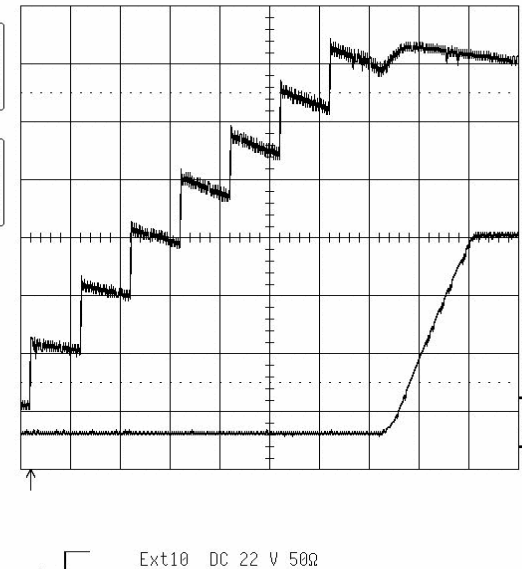- Booster rf gymnastics were stable (loops closed)

# AGS-to-RHIC Synchro

- Continued pursuit of less shot-to-shot jitter
  1. Change the loop compensator to one that does not include the radius signal (only good for a factor of 2 in synchrotron freq.)
  2. Replace obsolete "ramp-down" hardware
  3. Implement higher frequency phase detection
     1. blend from h=4 to h=12
     2. Tested with protons but not operational

- Develop new technique for precise phase measurement
  1. Eventual solution is precise open-loop cogging (like yellow to blue)
  2. Will be enabled by new digital llrf for AGS
  3. Benefit will be lower longitudinal emittance (vertex)

# Replace Debunch/Rebunch at AGS Injection

- The debunched state is a weak link
  - We need very low $\Delta p/p$ because ($\Delta E \, \Delta T$) must be conserved during debunching
  - Low $\Delta p/p$ leads to instability (transverse)
  - Thresholds go as $(\Delta p/p)^2 \rightarrow 1/12$
- This makes a compromise between low longitudinal emittance and intensity
- To remove the weak link we can eliminate the debunched state
- A bunched-beam adiabatic merge is possible
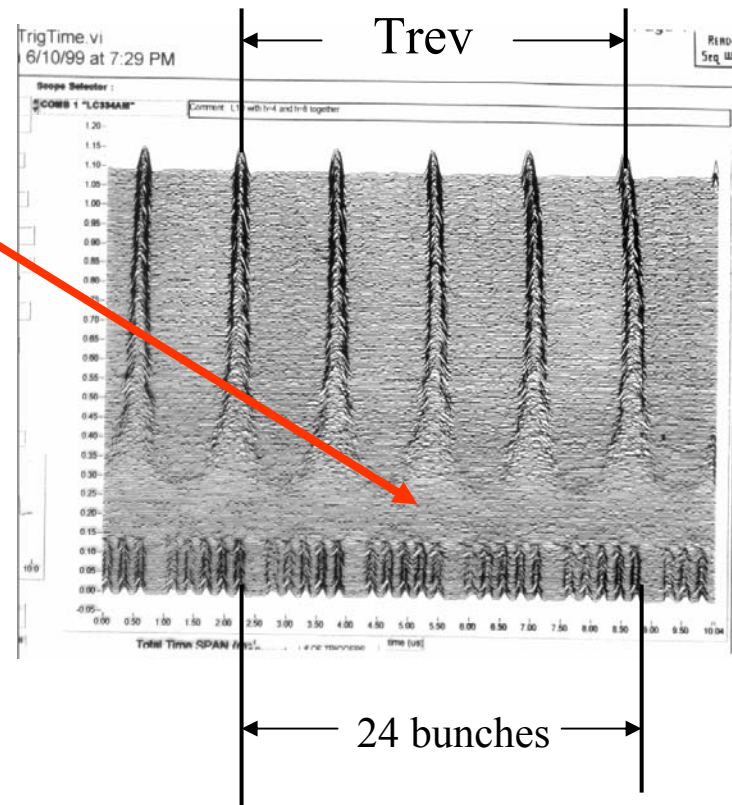
# Merge 24 to 4 Bunches

- Start with 3 to 1 merge, h=24 to h=8
  - Main rf on h=24 ramps down
  - Dedicated AGS cavity at h=16 ramps up (9 left)
  - Simultaneously L10 (Finemet cavity) ramps up at h=8
- Follow with 2 into 1 merge
  - L10 cavity morphs from h=8 to 4 to capture 4 RHIC bunches
  - The 9 main rf cavities ramp up at h=12 and accelerate to extraction (as always)
- The beam is always bunched,
  - Low $\Delta p/p$ instability is avoided
  - No "baby bunches" should be created
  - Loops on, implies less tweaking

# Comparing the Priorities
## [options are orthogonal (almost*)]

| Job | Bunch intensity | Reducing longitudinal emittance (vertex) | Man Hours | Urgency | My proposals |
|---|---|---|---|---|---|
| Booster 2 – 1 Merge Squeeze | Increase | No Improvement | High | TBD | No Contingency only |
| ATR Synchro | No change | Improve | Moderate | Low | Yes |
| 24 to 4 Merge | No change (Remove obstacle)* | No improvement | Moderate | High | Must Do (over due) |

# Summary

- We have some options to increase bunch intensity and reduce longitudinal emittance from the injectors
- I think we should,
  1. Work to improve ATR synchro
     1. Prep work before beam: 1 man week
     2. Normal synchro setup with beam: 1 shift
     3. Stay with it through teething problems
  2. Make the 24 to 4 merge in the AGS standard operation
     1. Setup once the high level is up: 2 days (all hands)
     2. Setup with beam (before RHIC is ready): 3 shifts (llrf experts)
  3. Hold the Booster  Merge/Squeeze as contingency
     1. Prepare necessary high level rf
     2. Dust off bricologe and home brew software
     3. Employ only if beyond $1 \times 10^9$ Au ions is called for